

Regional Economic Importance of the S.F. Water System

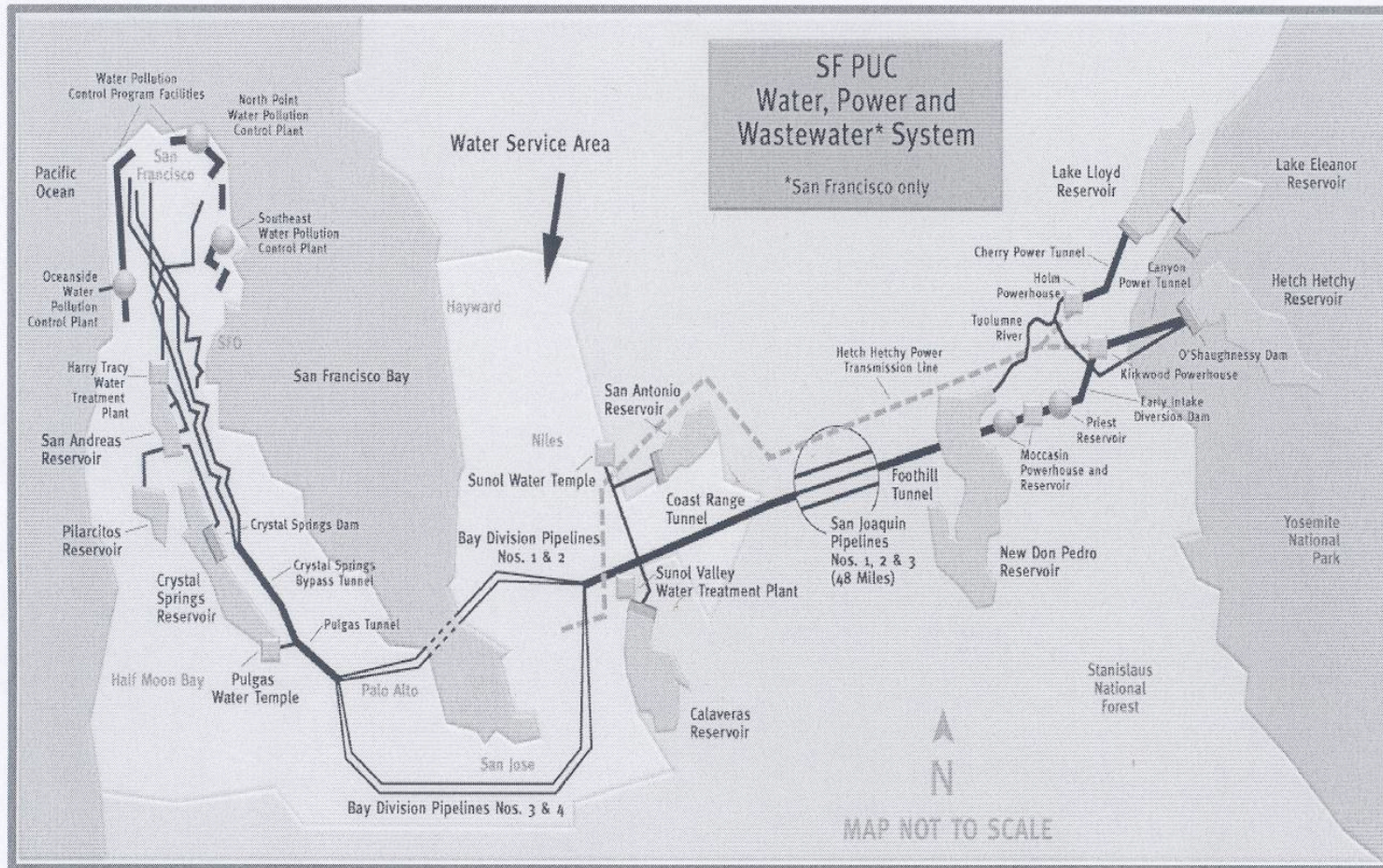
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Hetch Hetchy Water System

- Completed in 1934
- 167-mile, gravity-driven system
- Network of dams, reservoirs, tunnels, pump stations, aqueducts and pipelines
- Collects Tuolumne River runoff near Yosemite Valley

SFPUC Regional Water System



Map 1: SFPUC Regional Water System

Supplies and Demands

- In 2000-2001, system delivered 260 mgd
- Regional system: Customers in San Francisco and 29 wholesale buyers
- System supplies water to San Francisco, Santa Clara and Alameda Counties
- 85% was Hetch Hetchy water and 15% was from local sources
- San Francisco uses about one-third of SFPUC water
- 18 of 29 wholesale customers are wholly dependent on SFPUC water, and another 3 are at least 75% dependent

Strains to the System

- Limited capacity, age and vulnerability to catastrophe
- Hetch Hetchy's major components are over 50 years old
 - Some, including Crystal Springs and San Andreas Dam, pre-date Hetch Hetchy back to the 1870s
 - Facilities of most concern were built in 1920s and 1930s
- System crosses at least 5 active faults
 - San Andreas, Hayward, Calaveras, Greenville, Great Valley Fault Zone
 - Major earthquake on at least one of these faults is 70% likely by 2030
- Focus on earthquake impacts
- Also briefly consider drought risk

Economics of Earthquake Risk

- Characterize Underlying Risks
- Understand System Implications -- What will Fail?
- Consequences for Water Supplies
- Impacts by Customer Class
- Incremental Fire Damage
- Totals

Scenarios

- 7.9 Earthquake on San Andreas Fault
 - Most critical pipelines, tunnels, pumping stations from Newark west and north up the Peninsula are assumed to fail
 - Peninsula and city customers are shut off from Hetch Hetchy system, as are South Bay customers west of Milpitas
 - Pressure drops in the gravity-driven system, making it difficult to move stored supplies
 - Leaks systemwide exacerbate the pressure problem
 - Intertie with SCVWD may not be operational -- assume it is not a reliable source of supply

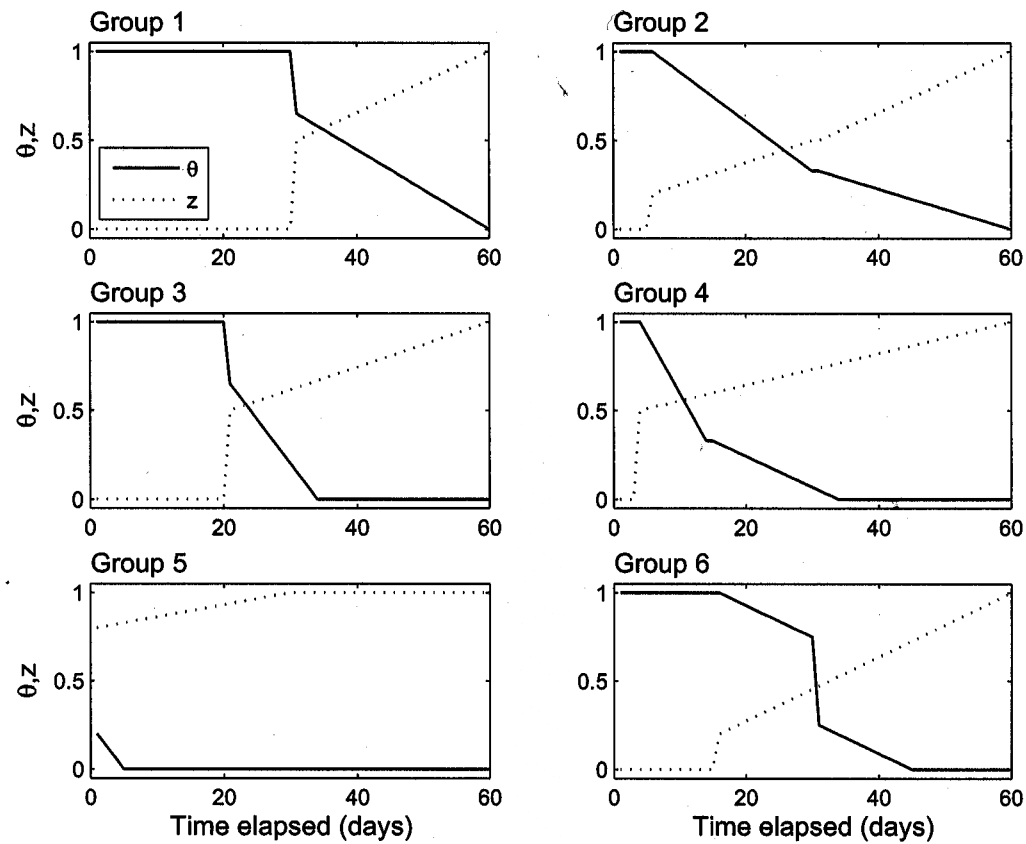
Scenarios

- 7.1 Earthquake on Hayward Fault
 - San Antonio Pump Station and Sunol Valley Water Treatment Plant are damaged; Alameda Siphons fail; Irvington Tunnel west portal collapses; Bay Division Pipelines rupture
 - Pressure drops again
 - South Bay customers served by turnouts from BDPLs are dependent on local storage; Peninsula and SF systems are operational but cut off from upstream Hetch Hetchy supplies
 - Harry Tracy Treatment Plant is ramped up -- enough to serve Peninsula and SF, but not enough if the BDPLs are damaged; South Bay customers would receive at most 50% of demand
 - SCVWD and Milpitas intertie could sustain direct damage

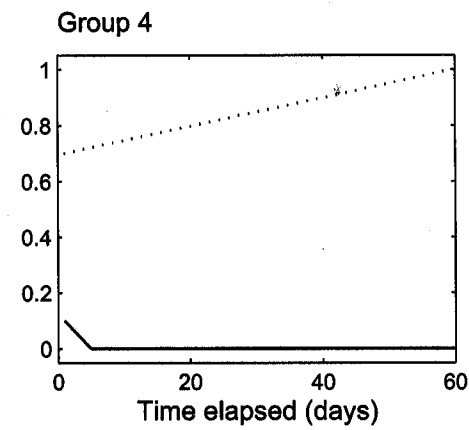
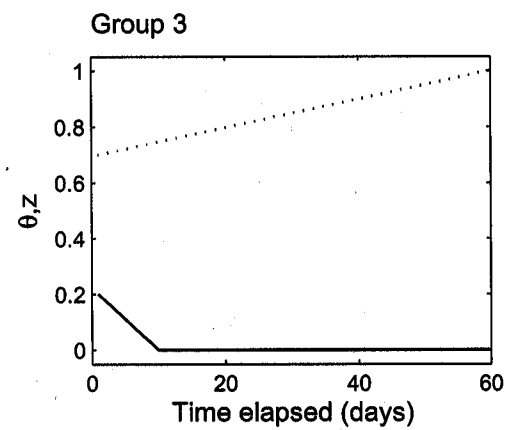
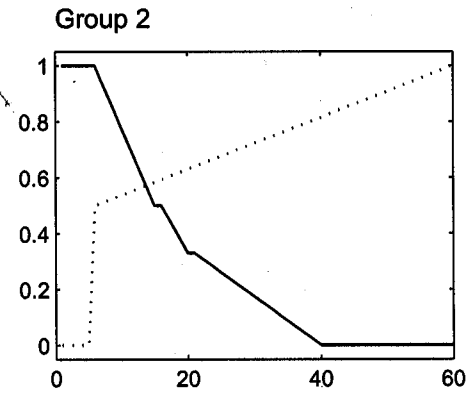
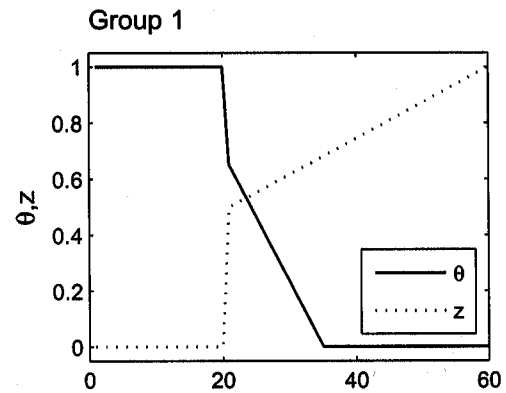
Implications

- Some portion of SFPUC customers will experience a complete loss of water supply
- Those customers that still receive water will experience rationing during the repair and recovery period
- Divide agencies into customer groups: 6 for San Andreas scenario, 4 for Hayward scenario

Outages: San Andreas



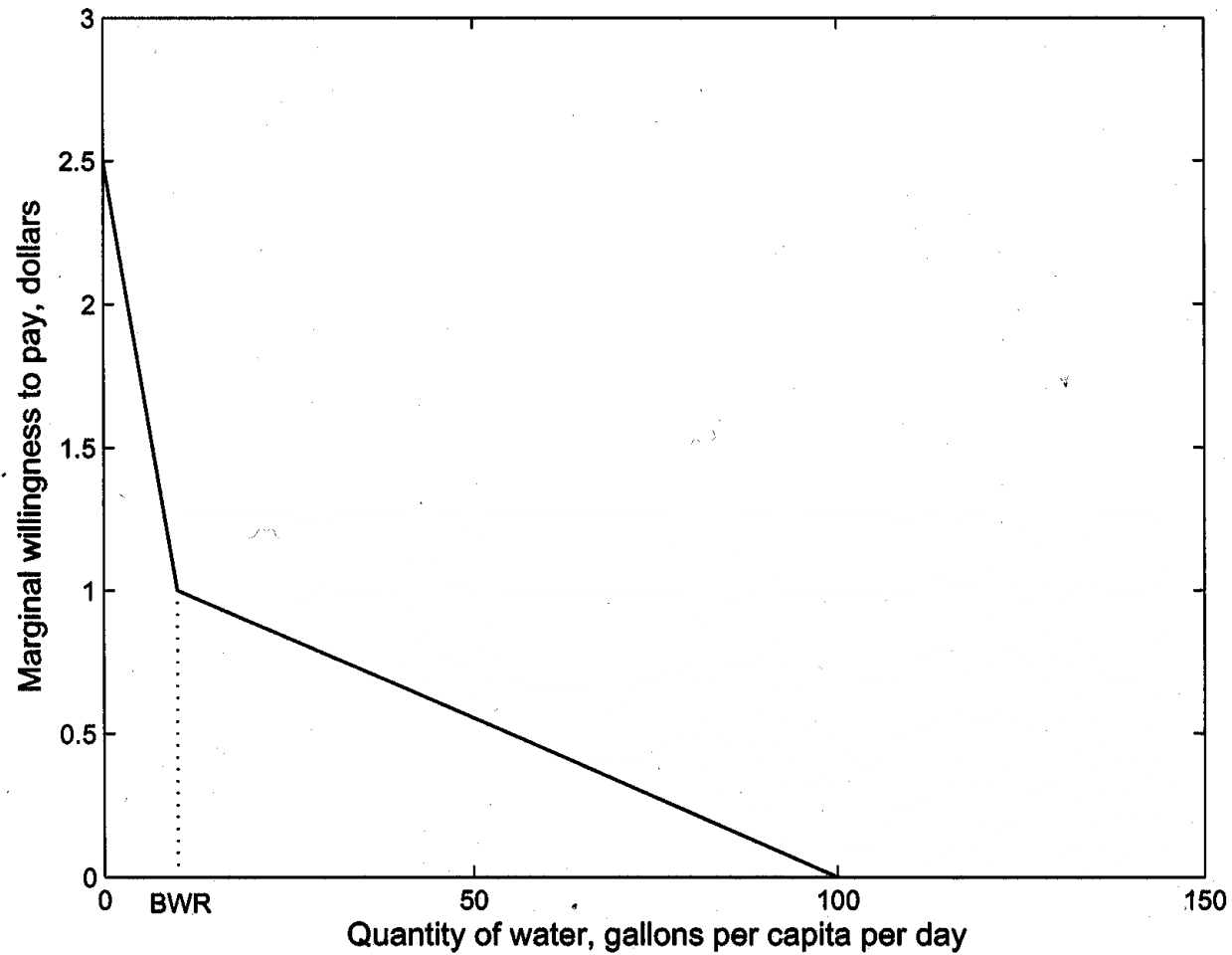
Outages: Hayward



Residential Sector Losses

- Damages measured as WTP to avoid a reduction/break in service
- Wide variation in water use in Bay Area
 - 50 gcd in East Palo Alto; 321 gcd in Purissima Hills
 - Reflects differences in outdoor use
 - In turn related to income, weather, other factors
- High WTP for basic sanitation, less for other uses

Residential Customer Loss Curve



Residential Losses: San Andreas

Group number	Water agencies	Residential welfare loss
1	Brisbane, Burlingame, CWS - Mid Peninsula, CWS - South San Francisco, Estero, Guadalupe Valley, Hillsborough, Millbrae, North Coast, Westborough	\$1,038
2	Daly City, San Bruno	\$204
3	Belmont, CWS – Bear Gulch, Cordilleras, East Palo Alto, Los Trancos, Menlo Park, Palo Alto (City), Purissima Hills, Redwood City, San Jose, Skyline	\$552
4	Milpitas, Mountain View, Santa Clara, Stanford, Sunnyvale	\$375
5	Alameda, Hayward	\$22
6	San Francisco	\$1,582
		Total \$3,774

Notes: Time paths of water supply interruptions and rationing by group follow Figure 4. Welfare losses are reported in millions of dollars.

Residential Losses: Hayward

Group number	Water agencies	Residential welfare loss
1	CWS – Bear Gulch, <i>Cordilleras</i> , East Palo Alto, Hayward, <i>Palo Alto (City)</i> , <i>Redwood City</i> , <i>San Jose</i> , Skyline	\$514
2	Alameda, Milpitas, Santa Clara, Stanford, Sunnyvale	\$766
3	San Francisco	\$122
4	Belmont, Brisbane, Burlingame, CWS - Mid Peninsula, CWS - South San Francisco, Coastside, <i>Cordilleras</i> , Daly City, Estero, Guadalupe Valley, Hillsborough, Los Trancos, Menlo Park, Millbrae, Mountain View, North Coast, <i>Palo Alto (City)</i> , Purissima Hills, <i>Redwood City</i> , San Bruno, <i>Stanford</i> , Westborough	\$73

Total \$1,475

Notes: Time paths of water supply interruptions and rationing by group follow Figure 5. Welfare losses are reported in millions of dollars. Italics denote cities with partial shortages within the group; it is assumed that half of the daily water demand for these water providers is unaffected by an M 7.1 earthquake on the Hayward Fault.

Business Losses

- Interviews with commercial water users suggest two major impacts of service disruption:
 - Health and safety
 - Plant operations
 - Cooling (air conditioning, labs, servers, water cooled equipment)
 - Direct input to production (bottling)
 - Intel uses in excess of 1 mgd at its Santa Clara fab, nearly all Hetch Hetchy water
 - New United Motors Manufacturing, Inc. (NUMMI) plant in Fremont is designed to use Hetch Hetchy water
 - Roche Pharmaceuticals uses 2mgm at its Palo Alto research lab
 - 1 msf mall has 250,000 visitors per week and \$1 million/day in sales

Baseline Economic Activity

<i>Sector</i>	<i>Manuf.</i>	<i>Wholesale trade</i>	<i>Retail trade</i>	<i>Prof. and Tech.</i>	<i>Accomm. and Food</i>	<i>Total</i>
<i>San Francisco County</i>	\$3,979	\$12,219	\$6,795	\$9,017	\$3,283	\$35,293
<i>San Mateo County</i>	\$6,690	\$14,663	\$7,335	\$3,235	\$1,380	\$33,303
<i>Santa Clara County</i>	\$72,528	\$68,095	\$16,674	\$10,441	\$2,592	\$170,330
<i>Alameda County</i>	\$22,338	\$47,791	\$12,405	\$3,875	\$1,574	\$87,983
<i>Total</i>	\$105,535	\$142,768	\$43,209	\$26,568	\$8,829	\$326,909

Table 3. Total value of shipments for the five sectors used in the production loss analysis for San Francisco, San Mateo, Santa Clara and Alameda Counties. All figures are in millions of dollars. Data from the 1997 Economic Census, U.S. Census Bureau.

Business Losses: San Andreas Scenario

Group	Manuf.	Wholesale	Retail	Prof./Tech.	Acc./Food	Group Total
1	247 <i>245-250</i>	541 <i>538-547</i>	270 <i>269-274</i>	119 <i>119-121</i>	51 <i>51-52</i>	1,228 <i>1,222-1,244</i>
2	195 <i>179-226</i>	428 <i>393-495</i>	214 <i>197-248</i>	94 <i>87-109</i>	40 <i>37-47</i>	971 <i>893-1,125</i>
3	2,267 <i>2,231-2,332</i>	2,329 <i>2,292-2,396</i>	660 <i>650-679</i>	381 <i>375-392</i>	108 <i>107-111</i>	5,745 <i>5,655-5,910</i>
4	1,257 <i>1,221-1,305</i>	1,181 <i>1,147-1,225</i>	289 <i>281-300</i>	181 <i>176-188</i>	45 <i>44-47</i>	2,953 <i>2,869-3,065</i>
5	25 <i>23-27</i>	53 <i>49-58</i>	14 <i>13-15</i>	4 <i>4-5</i>	2 <i>2-2</i>	98 <i>91-107</i>
6	361 <i>349-386</i>	1,108 <i>1,071-1,186</i>	616 <i>596-660</i>	818 <i>790-875</i>	298 <i>288-319</i>	3,201 <i>3,094-3,426</i>
Sector	4,352	5,640	2,063	1,597	544	14,196
Total	<i>4,248-4,526</i>	<i>5,490-5,907</i>	<i>2,006-2,176</i>	<i>1,551-1,690</i>	<i>529-578</i>	<i>13,824-14,877</i>

Notes: Group definitions and time paths of water supply interruptions and rationing follow Figure 4. Damage figures are reported in millions of dollars. Italicized values are estimates derived using high and low business resilience estimates (corresponding to γ_{jt} values of 0.2 and 0.5, respectively).

Business Losses: Hayward Scenario

Group	Manuf.	Wholesale	Retail	Prof./Tech.	Acc./Food	Group Total
1	1,977	2,551	728	352	113	5,721
	<i>1,947-2,033</i>	<i>2,512-2,623</i>	<i>717-749</i>	<i>346-362</i>	<i>111-116</i>	<i>5,633-5,883</i>
2	1,338	1,619	406	201	58	3,622
	<i>1,312-1,372</i>	<i>1,587-1,660</i>	<i>398-416</i>	<i>198-207</i>	<i>57-60</i>	<i>3,552-3,715</i>
3	26	79	44	58	21	228
	<i>23-30</i>	<i>70-91</i>	<i>39-51</i>	<i>51-68</i>	<i>19-25</i>	<i>202-265</i>
4	107	126	42	22	7	304
	<i>89-132</i>	<i>104-156</i>	<i>35-52</i>	<i>18-28</i>	<i>6-9</i>	<i>252-377</i>
Sector	3,448	4,375	1,220	633	199	9,875
Total	<i>3,371-3,567</i>	<i>4,273-4,530</i>	<i>1,189-1,268</i>	<i>613-665</i>	<i>193-210</i>	<i>9,639-10,240</i>

Notes: Group definitions and time paths of water supply interruptions and rationing follow Figure 5. Damage figures are reported in millions of dollars. Italicized values are estimates derived using high and low business resilience estimates (corresponding to γ_{jt} values of 0.2 and 0.5, respectively).

Fire Damage: San Andreas

Wind Speed Scenario	Probability	Fire damage to property	Water supply interruption excess damage	Excess damage to property at risk	Expected damage (billions)
0 – 15 mph	0.70	1.5%	25 – 50%	0.56%	\$3.9
15 – 30 mph	0.28	3.3%	25 – 100%	2.06%	\$5.8
>30 mph	0.02	5.5%	25 – 150%	4.81%	\$1.0

Total expected damage **\$10.7**

Table 6. Estimate of property damage related to fire following earthquake with water supply interruption, M 7.9 San Andreas Fault earthquake scenario. Wind speed scenarios, probabilities and baseline damages are based on Scawthorn (1987). Damage estimates assume a total of \$1 trillion of property at risk.

Fire Damage: Hayward

Wind Speed Scenario	Probability	Fire damage to property	Water supply interruption excess damage	Excess damage to property at risk	Expected damage (billions)
0 – 15 mph	0.70	0.8%	25 – 50%	0.30%	\$2.1
15 – 30 mph	0.28	1.8%	25 – 100%	1.13%	\$3.2
>30 mph	0.02	3.0%	25 – 150%	2.63%	\$0.5
<i>Total expected damage</i>					<i>\$5.8</i>

Table 7. Estimate of property damage related to fire following earthquake with water supply interruption, M 7.1 Hayward Fault earthquake scenario. Wind speed scenarios, probabilities and baseline damages are based on Scawthorn (1987) and Scawthorn *et al.* (1993). Damage estimates assume a total of \$1 trillion of property at risk.

Projected Losses

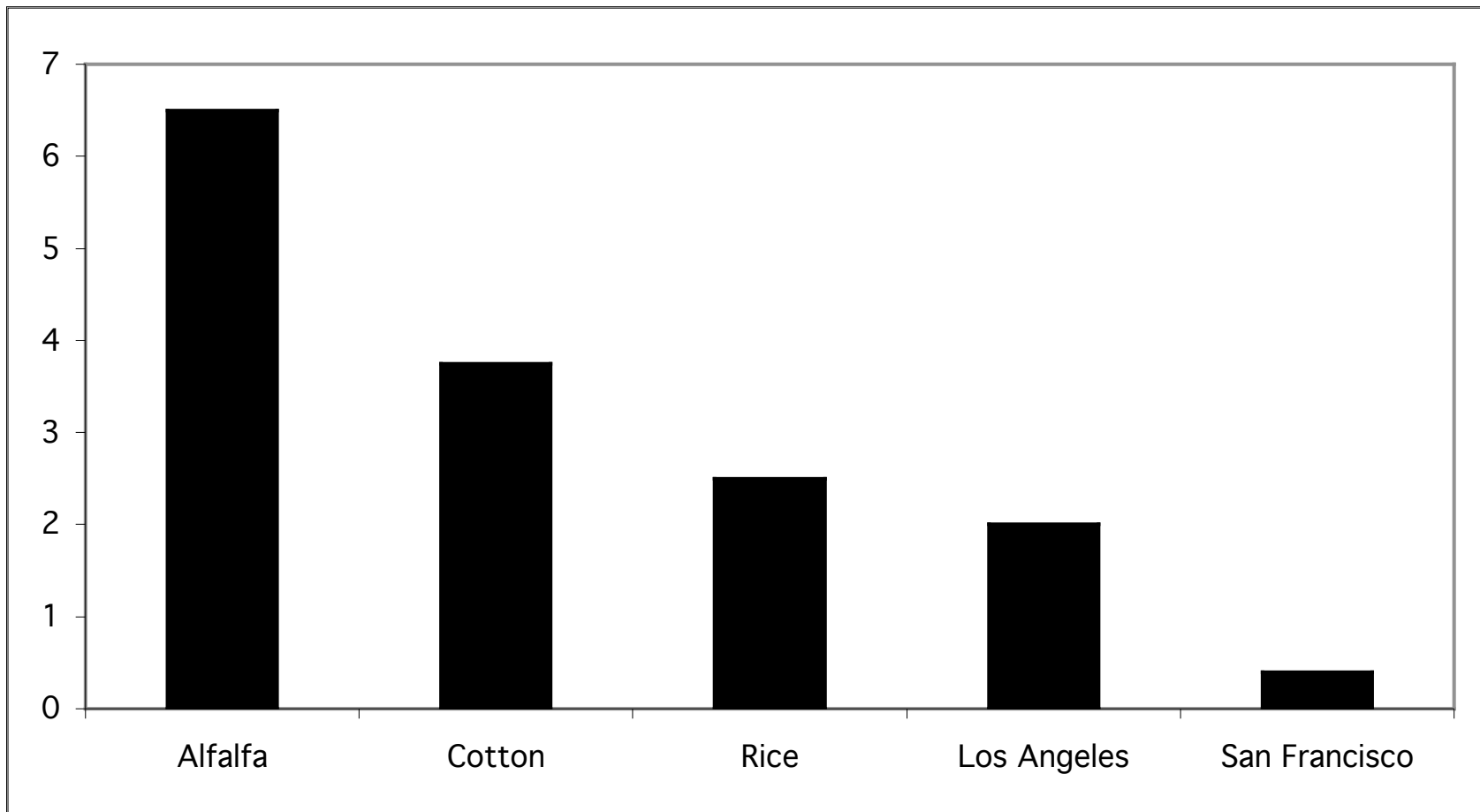
Projected Losses from Water Service Interruption (By Type of Seismic Event)

	<u>San Andreas Fault (7.9)</u>	<u>Hayward Fault (7.1)</u>
Residential Losses	\$ 3.8 billion	\$ 1.5 billion
Business Losses		
Manufacturing	\$4.35 billion	\$3.45 billion
Wholesale/Retail	7.70 billion	5.60 billion
Professional/Scientific/Technical	1.60 billion	0.63 billion
Lodging/Food Services	0.54 billion	0.20 billion
Total Business Losses	\$14.2 billion	\$9.9 billion
Fire Damage (from inadequate water supplies)	\$10.7 billion	\$5.8 billion
Total Estimated Losses:	\$28.7 billion	\$17.2 billion

Drought Risk

- Most urban areas of California are vulnerable to drought risk
- Current estimates indicate SFPUC customers could experience up to 20% rationing
- Wide variation in water use and marginal values of water
- Indicates that *how* shortage is allocated will be crucial
- Shortage-sharing and trading arrangements among SFPUC customers

Some perspective...



Supply Augmentation

- Little will to expand surface storage
- But other options exist
 - Dry-year purchases from farmers
 - Groundwater banking
 - System inerties
- Interesting question is to compare cost of 20% rationing (conservation) with cost of bringing supplemental water to region

Go Bears!